BREEDING HABITS AND ASSOCIATED PHENOMENA IN SOME INDIAN BATS

PART IV—*HIPPOSIDEROS FULVUS FULVUS* (GRAY)—HIPPOSIDERIDAE[1]

A. Madhavan, D. R. Patil and A. Gopalakrishna[2]

(*With two plates*)

The breeding biology of *Hipposideros fulvus fulvus* has been described based on the examination of 624 specimens collected at and around Nanded in Marathwada, Maharashtra State. The specimens were collected at frequent intervals during a period of two years from September 1964 to October 1966. This species has a strict sexual periodicity. Copulation, followed by ovulation fertilization and pregnancy occurs in the middle of November. All deliveries in the colony occur within a short span of about two weeks between the last week of April and the first week of May. Gestation lasts for about 150 to 160 days. A single young is delivered by each female during each cycle. The left side of the female genitalia is physiologically dominant, and ovulation and pregnancy occur in the left side of the genitalia more than in the right. The young are carried by the mothers at their breast continuously for 20 to 22 days during which period the young ones grow rapidly. Sexual maturity is not attained by either sex until the animals are at least 18 to 19 months of age. There is an uneven female-dominant sex ratio in the adult stage.

Material and methods

The specimens of *Hipposideros fulvus fulvus* were collected at and around Nanded, Marathwada region, Maharashtra State, India. The collection was started on 29th September 1964 and continued until 17th October 1966 in such a manner that every calendar month is represented by one collection or more. During the breeding season as many collections as possible were made with a view to obtaining closely graded developmental stages and to arriving at an accurate pregnancy record. Altogether 624 specimens were examined for the present report.

Hipposideros fulvus fulvus is a small bat which is found in underground food cellars and dark recesses of old houses and dilapidated buildings. The specimens were collected at random with the help of butterfly nets. They were killed by chloroform and their body weights were taken, and, in the majority of cases, the length of the forearm, ear pinna, head and left wing were also recorded. After recording observations on the disposition of the external genitalia, teats, position of the testes and other genital organs, the reproductive organs and the accessory reproductive structures in both the sexes were dissected out and fixed in various fixatives such as Bouin's fluid, Carnoy's fluid and neutral formalin. After 24 hours of fixation the tissues were transferred to 70% ethanol, in which they were preserved. The weight of the right testis of all the males was recorded after fixation and preservation in 70% ethanol. Further processing of the tissues for preparing stained sections was carried out as detailed in the previous parts of these studies.

[1] Accepted October 1975.

[2] Department of Zoology, Institute of Science, Nagpur.

The group of specimens collected on a given calendar date presented almost the same condition during the two years when the observations were made. Hence, in the following descriptions only the date and the month are mentioned where pertinent, except where the mention of the year has a special significance.

A detailed collection diary giving the salient characters of each specimen was maintained. Table I gives the summary of the collection diary and Table II gives the monthwise collection of the specimens.

TABLE I
SUMMARY OF COLLECTION DIARY

Date	Males				Females							
	Immature		Adult		Immature		Adult					
	Attached to mother	Free	Total of males		Attached to mother	Free	Non-pregnant	Pregnant		Lactating	Total of females	Grand total
								Right horn	Left horn			
1	2	3	4	5	6	7	8	9	10	11	12	13
1-1-65	—	—	—	—	—	—	—	—	2	—	2	2
2-1-65	—	—	3	3	—	—	—	1	1	—	2	5
12-1-65	—	—	1	1	—	—	—	—	1	—	1	2
15-1-65	—	1	7	8	—	—	4	5	7	—	16	24
20-1-65	—	—	3	3	—	—	1	1	9	—	11	14
21-1-66	—	—	—	—	—	—	—	3	4	—	7	7
28-1-65	—	—	1	1	—	—	—	—	3	—	3	4
1-2-65	—	—	—	—	—	—	—	1	1	—	2	2
9-2-65	—	—	4	4	—	—	—	—	2	—	2	6
17-2-66	—	—	1	1	—	—	—	2	4	—	6	7
27-2-66	—	—	—	—	—	—	—	1	—	—	1	1
9-3-65	—	—	—	—	—	—	—	—	4	—	4	4
12-3-66	—	—	1	1	—	—	—	1	—	—	1	2
15-3-65	—	1	—	1	—	—	1	1	7	—	9	10
18-3-65	—	—	2	2	—	—	—	5	8	—	13	15
23-3-65	—	—	—	—	—	—	—	4	5	—	9	9
26-3-65	—	—	2	2	—	—	—	4	8	—	12	14
23-4-65	1	—	1	2	—	6	—	—	1	1	2	4
25-4-66	2	—	—	2	2	—	—	2	—	4	8	10
26-4-65	1	—	3	4	1	—	—	—	6	3	10	14
7-5-65	3	—	2	5	6	—	—	—	—	11	17	22
11-5-65	2	1	3	6	3	4	—	—	—	10	17	23
16-5-66	3	—	1	4	2	—	1	—	—	7	10	14
19-5-65	6	5	5	16	9	8	—	—	—	26	43	59
25-5-65	—	10	5	15	—	13	—	—	—	9	22	37
26-5-66	1	4	—	5	1	3	—	—	—	11	15	20
5-6-65	—	—	13	13	—	1	—	—	—	3	4	17
15-6-66	—	1	2	3	—	8	2	—	—	10	20	23
16-6-65	—	4	2	6	—	4	—	—	—	6	10	16
29-6-65	—	—	1	1	—	1	4	—	—	5	10	11
12-7-65	—	1	—	1	—	1	—	—	—	—	1	2

Table I (*Continued*)

Date	Males				Females							
	Immature		Adult		Immature		Adult					
	Attached to mother	Free	Total of males		Attached to mother	Free	Non-pregnant	Pregnant: Right horn	Pregnant: Left horn	Lactating	Total of females	Grand total
1	2	3	4	5	6	7	8	9	10	11	12	13
14-7-65	—	—	9	9	—	—	3	—	—	—	3	12
1-8-65	—	—	3	3	—	—	16	—	—	—	16	19
11-8-65	—	1	1	2	—	1	13	—	—	—	14	16
11-8-66	—	—	5	5	—	—	4	—	—	—	4	9
28-8-65	—	—	2	2	—	—	3	—	—	—	3	5
10-9-65	—	—	5	5	—	2	—	—	—	—	2	7
10-9-66	—	—	—	—	—	—	3	—	—	—	3	3
29-9-64	—	—	4	4	—	—	7	—	—	—	7	11
29-9-65	—	—	1	1	—	—	1	—	—	—	1	2
1-10-65	—	—	2	2	—	—	8	—	—	—	8	10
8-10-65	—	—	4	4	—	—	1	—	—	—	1	5
11-10-64	—	6	7	13	—	—	9	—	—	—	9	22
17-10-66	—	—	1	1	—	1	10	—	—	—	11	12
28-10-64	—	9	3	12	—	—	10	—	—	—	10	22
13-11-65	—	—	—	—	—	—	4	—	—	—	4	4
15-11-65	—	—	3	3	—	—	—	—	—	—	—	3
16-11-64	—	—	6	6	—	—	5	—	—	—	5	11
22-11-65	—	—	7	7	—	1	—	—	3	—	4	11
28-11-64	—	—	3	3	—	—	7	—	—	—	7	10
6-12-65	—	—	1	1	—	—	—	2	1	—	3	4
10-12-64	—	3	1	4	—	1	—	—	—	—	1	5
16-12-64	—	—	—	—	—	—	1	—	—	—	1	1
17-12-64	—	1	1	2	—	—	1	4	2	—	7	9
20-12-65	—	—	2	2	—	—	1	—	1	—	2	4
28-12-64	—	—	3	3	—	—	—	1	3	—	4	7

TABLE II

MONTHWISE COLLECTION OF SPECIMENS

Month	Males	Females	Total
Jan.	16	42	58
Feb.	5	11	16
Mar.	6	48	54
Apr.	8	20	28
May	51	124	175
Jun.	23	44	67
Jul.	10	4	14
Aug.	12	37	49
Sep.	10	13	23
Oct.	32	39	71
Nov.	19	20	39
Dec.	12	18	30
Grand total	204	420	624

OBSERVATIONS AND CONCLUSIONS

1. General remarks on *Hipposideros fulvus fulvus.*

Hipposideros fulvus fulvus is a small bat, the maximum weight of the male and of the non-pregnant female being about 10 gm. The other maximum measurements are as follows: wing span—13 cm in both sexes; forearm—4.2 cm in both sexes; ear pinna—2 cm in female and 2.1 cm in male; head length—2.3 cm in female and 2.5 cm in male. The fur on the dorsal side is dark grey and that on the ventral side is immaculate or greyish white. This species chooses dark, cool and damp

places for roosting in such a way that a water tap or a shallow well and a shady tree are present in the vicinity of the cellar so that the roosting place gets as much moisture and shade as possible. It is very seldom that these animals emit an audible sound, but the presence of a colony of *Hipposideros fulvus fulvus* is easily detected by a characteristic odour. They are very active and swiftly fly away if there is even a slight disturbance. In the resting position they remain freely suspended from the ceiling. The specimens roost isolated and free from one another and are never seen in clusters (fig. 1). While they are in the resting position, they show constant movements by swinging their bodies, moving their heads in a rotary motion, flapping their wings and often changing their position in the colony. A colony usually has about 50 to 100 specimens. They leave their underground cellars late in the evening for feeding. On several occasions, when the roosts were visited at about 11 O' clock in the night, the specimens were still found flying about in the cellar, but not flying out of the cellar. Dead bodies of cockroaches and of beetles were often found in the cellars where these animals live. Males and females are found in the same colony irrespective of the age of the animals or the season. If the roost is visited frequently for collection of the specimens the bats leave the roost and do not return to the same roost for several weeks.

Attempts to keep them alive in the laboratory were not successful as the animals are very delicate and do not survive in captivity under normal humidity. However, the specimens survive for a day or two if a wet cloth or a wet pad of cotton is placed in the cage and over the wire mesh of the cage.

The unweaned young ones are found to be attached to the mothers in the head-to-tail position during the resting non-sucking times. The young one holds one or some times both the pubic dugs in its mouth, and the hind limbs are kept free, or in a loose embrace, round the neck of the mother. While sucking (fig. 2) the young holds the mammary nipple by the jaws, and the claws of the hind feet are firmly anchored to the pubic dugs. When the young one is able to fly, it remains separated from the mother, but occasionally attaches to one of the mothers in lactation for sucking. Before doing so, it flies towards the mother and clings to a rough surface of the ceiling close to the mother, and, with a sudden swing, gets a hold on the mother's body with the help of the claws in the hind limbs, and then holds the mother's mammary nipple by its jaws. The mother sometimes holds the skin of the back of the young in her mouth to prevent it from slipping down. Apparently, there is community suckling of the young after the young ones get free from the mothers, since it would be impossible for the young one to seek out its own mother in the colony.

2. Female reproductive organs.

The ovary is ellipsoidal in shape measuring about 1 mm long and 0.5 mm broad. The ovarian surface is warty. Each ovary is enclosed by a complete ovarian capsule and is attached to the dorsal ligament by a narrow hilus. The Fallopian tube on each side arises from the medial margin near the caudal end of the ovarian bursa. It takes a tortuous course around about the middle of the ovarian capsule, and bends caudally on the lateral side of the ovarian capsule and open into the respective uterine cornu.

As in all other bats, except in the members of the family Phyllostomatidae, the uterus is bicornuate ,and the two cornua are morphologically symmetrical. Each uterine cornu forms

a twisted arch bulging anteriorly, and is about 8 mm in length. The two cornua meet mesially and their lumina become confluent. There is a common broad cervical canal opening into the vagina. The vagina is about 6 to 7 mm long and opens by a transverse vulval opening.

The mammary glands are pectoral in position and are present on the ventro-lateral aspect of the thorax, one on each side. The mammary nipples, one on each side, are directed laterally. In the parous females there is a pair of prominant pubic dugs without mammary glands in the inguinal region, one on each side.

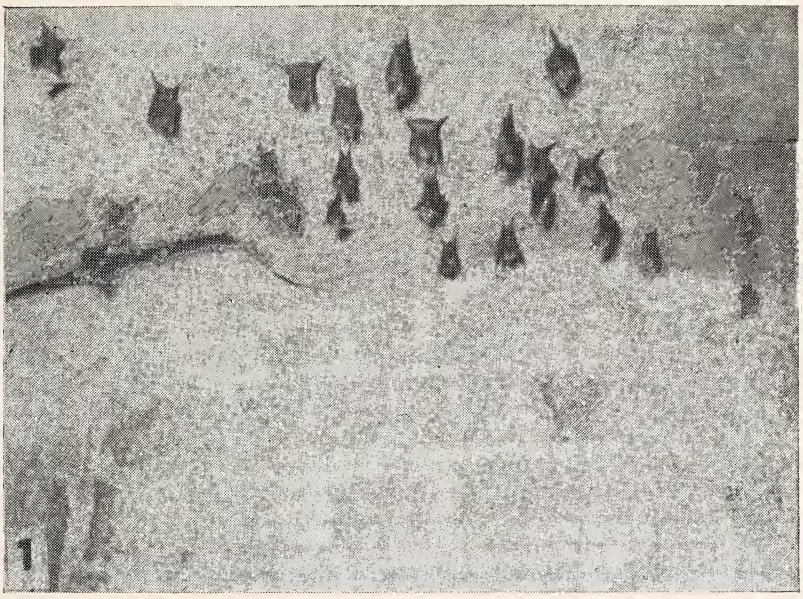
3. Breeding habits.

The examination of the collection diary and table I reveals some interesting features. Pregnancy occurs only during the months from about the middle of November to about the last week of April. Figures 3-8 are photographs of entire genitalia of many female specimens collected on different dates, and are intended to illustrate the condition of the female reproductive organs during the different months of the year. From the examination of the figures it is evident that progressively advanced stages of pregnancy occur from November to the following April. The above facts indicate that *Hipposideros fulvus fulvus* experiences a single reproductive cycle in the year .

Microscopic examination of the females revealed that copulation had not occurred in the females collected on October 28, but each of the females collected on November 13 had undergone copulation as evidenced by the presence of sperms in their uteri and Fallopian tubes. However, none of them had undergone ovulation, but in each specimen one of the ovaries had a fully formed Graafian follicle which was about to rupture. Of the five females collected on November 16, in four specimens the ovary of one side had an early corpus luteum, and in each of these specimens an egg in early cleavage was present in the Fallopian tube. The remaining female had, in one of the ovaries, a pre-ovulatory Graafian follicle. Each of the adult females collected on November 22 had an early blastocyst. In the females captured on November 28, early stages of implantation were noticed. On any given date during the period from December to April all the pregnant females were practically in the same stage of gestation. The above facts lead to the conclusion that all adult females undergo copulation in a sharply restricted period in about the second week of November after which, within a short time, ovulation and fertilization take place followed by pregnancy.

The first delivered young in the year, and which was a couple of days old, was collected on April 23. All the parous females collected on and after May 7 had delivered their young. Apparently, all deliveries in the colony had taken place within a short span of two weeks —the last week of April and the first week of May.

Females carrying young at the breast were collected from April 23 until May 26. But it is very unlikely that each young is carried by its mother for this duration of time. This is evidenced by the following facts: The heaviest young attached to the mother was 4.5 gm in weight, and the young leave their mothers after they reach this weight. The first batch of the free young ones of about this weight was collected on May 11. Evidently, these must have belonged to the first batch of young ones delivered around April 23. From this it is apparent that the mothers carry their young only for about 20 to 22 days, calculating from the date on which the first delivered young was



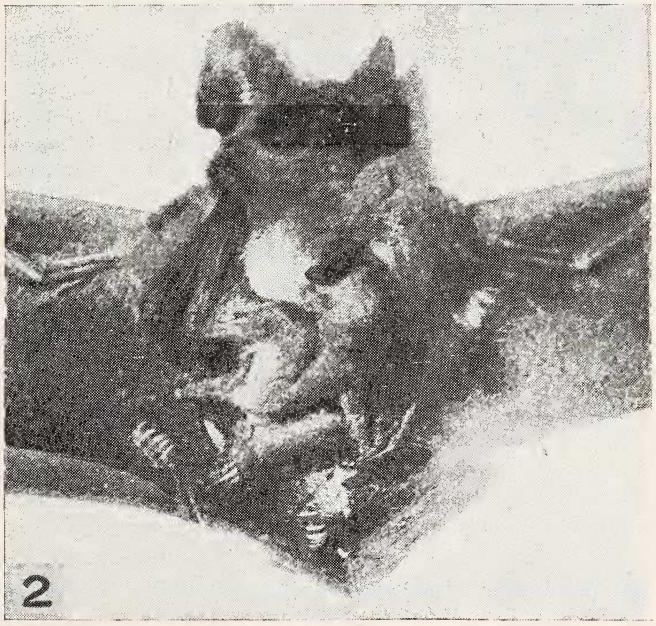
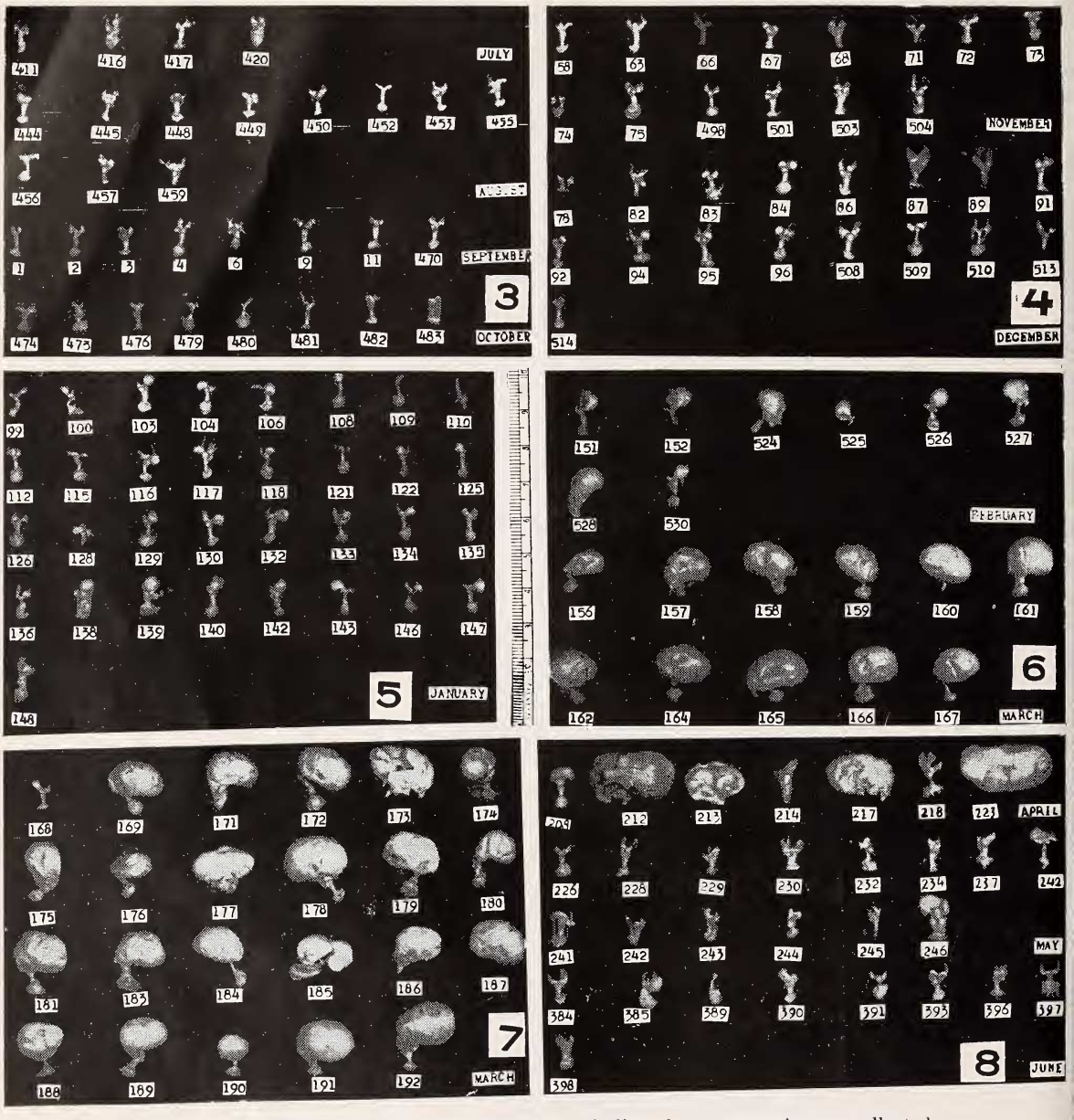


Fig. 1. A part of a colony of *Hipposideros fulvus fulvus*. Note the specimens hanging freely from the ceiling and remain isolated from one another without huddling together.

Fig. 2. Photograph of a mother suckling her young. The position of the young is reversed while it is not sucking milk.



Figs. 3-8. Photographs of entire female genitalia of some specimens collected during several months of the year. Note that progressively advanced stages of pregnancy occur from November to April. During the pregnant season there are a few non-pregnant specimens also (Nos. 110, 115, 121, 128, 135, 168) indicating that not all the females become pregnant in the breeding season. Pregnancy is not noticed during the other months.

collected (April 23) to the date on which the first free young was collected (May 11) and allowing a margin of a couple of days. However, even after they leave their mothers the young ones probably visit lactating mothers for sucking for some time more. This is indicated by the facts that curdled milk was present in the stomach of several free young, and the mammary glands of the mothers continue to be in lactation for quite some time after the young ones leave their mothers. Females in lactation were collected until July 29.

From the foregoing account of the breeding habits of *Hipposideros fulvus fulvus* the annual life of the females of this species can be recognized into the following periods:—

(1) Period of sexual inactivity from about the end of June to the beginning of November.
(2) Copulation in the second week of November.
(3) Pregnancy from about the middle of November until about the end of April.
(4) Parturition during the last week of April and the first week of May.
(5) Lactation until the end of June.

4. Gestation.

It has been already mentioned that the females collected on November 13 had not ovulated even though they had undergone copulation. But in some of the females collected on November 16 very early cleavage stages of the egg were present indicating that fertilization might have taken place about a day or two before. The first date on which a delivered young was obtained was April 23, and from the condition of the young it can be presumed that this might have been delivered just a couple of days before. This conclusion is based on the following facts:—the young was completely naked wihout any visible fur; the eye lids were adherent; a withered umbilical cord was still present; it had a body weight of 2.2 gm, which is also the maximum weight of the full term foetus. From the foregoing it is evident that the gestation period of *Hipposideros fulvus fulvus* is about 150 to 160 days, allowing a margin of a couple of days on either side.

5. Growth and maturity.

Mention has already been made that the young are all delivered in a sharply defined period between about April 22 and May 7. The new born young weighs about 2.2 gm (The maximum weight of the foetus in this species is also 2.2 gm). Immediately after birth the young one gets attached to the breast of its mother, and is carried by the mother until it attains a body weight of about 4.5 gm. After the young one reaches this weight it leaves the mother, although it may continue to suck milk occasionally for a few more days as evidenced by the fact that the young specimens weighing more than 4.5 gm were some times noticed in the act of sucking from the breast of mothers during the later half of May. The first batch of free young weighing 4.5 gm was collected on May 11. It has been mentioned that the young is carried continuously by the mother for about 20 to 22 days only. During this period the young one grows from 2.2 to 4.5 gm in weight, that is, it increases about twice in its weight. Mothers carrying young were collected until May 26. After this date it is hardly possible to distinguish the young from the adults on the basis of the size of the body. Evidently, the young one grows very rapidly during the early period, and by the time it leaves its mother it has grown very nearly to the adult size.